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THE ORIENTAL FRUIT MOTH
IN PENNSYLVANIA

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Quince destroyed by Oriental fruit moth

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SUMMARY

The Oriental Fruit Moth is one of the most dangerous orchard pests of today. It was first reported in harmful numbers in Pennsylvania in 1923 when it caused heavy losses in orchards of the southeastern section of the State.

At the present time it is found throughout the State except possibly in orchards in isolated sections. Outside of Pennsylvania it is widespread in the United States east of the Mississippi River. It is also found in Canada.

The Oriental fruit moth causes injury in two ways. First, the larvae feed in the young shoots of the peach tree killing them back and causing them to take on a bushy growth. This type of injury is most serious on nursery stock. Second, the larvae feed in the fruit of peach, quince and apple. Serious injury has not been observed on apples but infestations of 75 per cent and even more are not unusual on quinces and late peaches. Much of this injury is not discovered until the fruit is cut open.

At present there is no satisfactory control for the moth. The following practices will aid in reducing the amount of injury.

1. Early cultivation prior to blossoming. This is good practice in the peach orchard regardless of its effect on the overwintering larvae.
2. Use of PDB (paradichlorobenzene) for peach borers each fall will kill overwintering larvae at the base of the tree.
3. Prompt removal and destruction of wormy fruit from the orchard.
4. Screening of packing houses to prevent escape of adults emerging from larvae overwintering in crates, baskets etc.
5. Five or more applications of nicotine sulfate at the rate of one pint to one hundred gallons of spray.

THE ORIENTAL FRUIT MOTH IN PENNSYLVANIA

By J. R. Stear*
Bureau of Plant Industry

The Oriental fruit moth (*Laspeyresia molesta* Busck) made its appearance in the United States in the vicinity of the District of Columbia some time prior to 1916. It is supposed to have been introduced into the country from Japan on nursery shipments of flowering cherry, peach and other trees.

The year 1923 marked the first appearance of this new pest in Pennsylvania in numbers great enough to cause commercial loss to fruit growers. Within two years it had spread into Franklin, Adams, York, Chester, Delaware, Philadelphia, Montgomery, Bucks, Berks, Lebanon, Dauphin, Lancaster, Cumberland, Perry, Northumberland and Schuylkill Counties. At the present time (1929), it is found throughout the State except possibly in very isolated orchards.

CHARACTER AND EXTENT OF INJURY

The early generations of larvae or worms bore into the growing tips of peach, killing them back for several inches (See Figs. 1 and 2). However in orchards with slight twig growth some of the larvae of this first generation will feed in the very young fruit. Later generations attack both twigs and fruit (See Fig. 3). The killing back of the terminals causes the tree to send out many lateral shoots resulting in a very bushy top. In some orchards under observation practically all the terminals had been injured by the boring habits of the larvae. Counts of infested fruits have shown as high as 75 per cent injury. Wormy peaches are not always easy to detect as the young larvae may enter the peach near or through the stem. This is especially true of ripe fruit. While examining a quantity of infested Elberta peaches this past season it was found that even by the most searching examination not over half of the wormy peaches could be detected from the outside. Gum and frass are usually exuded from the entrance holes in green fruit, a condition identifying the work of this insect. (See Fig. 3).

Peaches are favored as food by the Oriental fruit moth, but quinces and apples are also attacked, quinces being often completely destroyed by the feeding larvae (See cover page) although the sur-

*Photos by H. B. Kirk.

face of the fruit may show little evidence of the ruined interior. Usually the only external evidence in this case is the presence of rather clean holes about the size of a match stem leading from open galleries inside.



Fig. 1. Peach terminal destroyed by Oriental fruit moth larva.

SEASONAL AND LIFE HISTORY

The Oriental fruit moth overwinters in the larval or worm stage in slight cocoons, composed of particles of bark, frass and dirt in addition to the silk which holds this matter together. They are found in the drier situations on the trunks of trees, beneath loose bark, (See Fig. 4) in cracks and crevices on the bark, in tight crotches, in old borer holes, in mummied fruit on the trees, in curls of peach bark but rarely on bark in exposed places. According to Dr. Stearns in New Jersey, a majority of the larvae spin up in trash

on the ground away from the tree. This is especially true when large numbers of infested fruits fall to the ground.

The overwintering larvae which consist of larvae of the 3rd, 4th and 5th generations of the previous season, pupate late in March and early in April. Adult emergence begins about April 20th and continues for three or four weeks except in the case of adults from sheltered locations such as packing houses. Emergence from such locations continues until late in June.

The first eggs are deposited early in May and the first hatching occurs 15 to 20 days later. This is about a week or ten days after shuck fall. Adults of the first generation begin to emerge from the 15th to the 20th of June; 2nd generation adults about July 20th; 3rd



Fig. 2. Dormant peach twigs showing Oriental fruit moth damage.

generation adults about August 20th; and 4th generation adults about September 20th. The life cycle is completed in 25 or 30 days except early and late in the season when it may require 40 to 50 days.

Studies made during the past four years at Chambersburg show that there are four generations and in some years at least a small fifth generation in the southern part of the State. In 1928 there were five generations, fourth generation adults emerging on September 19th.

Due to irregular emergence, there is considerable overlapping of the generations after the first one. From the time the first adult

emerges in the spring adults are present throughout the season and eggs may be found from early May until the middle of October. Table 1 shows the occurrence of the different generations in 1928. The beginnings of the various stages are indicated quite accurately but the length of time over which they extend is not completely shown as the studies were continued only long enough to show the number of generations.

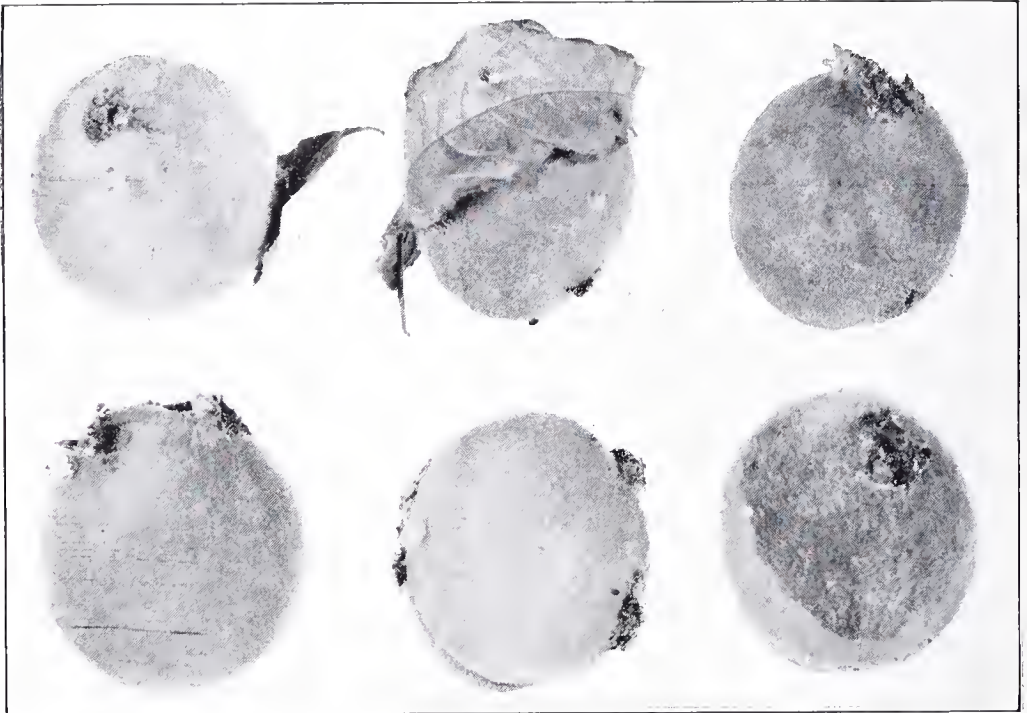


Fig. 3. Young peaches infested with Oriental fruit moth.

Table 1. Seasonal history of the Oriental fruit moth at Chambersburg, Pa. 1928.

Generation and stage	April	May	June	July	Aug.	Sept.	Oct.	Overwintering
Overwintering adults ---	XXX	XXXXXX	XXX					
1st Gen. Eggs -----		XXXXXX	XXXXX					
1st Gen. Larvae -----		XXX	XXXXXX					
1st Gen. adults -----			XXXX	XXX				
2nd Gen. eggs. -----			XXX	XXXXX				
2nd Gen. larvae -----			XX	XXXXXX				
2nd Gen. adults -----				XXXX	XXXXX			
3rd Gen. eggs -----				XX	XXXXX	XXXXX	XXXXX	XXXXXXXXXX
3rd Gen. larvae -----					XXXX	XXXXX	XX	
3rd Gen. adults -----					XX	XXXX		
4th Gen. eggs -----					X	XXXXX	XXXXX	XXXXXXXXXX
4th Gen. larvae -----						XX		
4th Gen. adults -----								
5th Generation. No eggs were secured from the 4th generation adults.								

DESCRIPTION OF STAGES

The Eggs. The eggs are about the size of a pinhead, transparent when empty, or milky translucent and iridescent before hatching. The center is whitish or grayish with a slight polish. A day or so

before hatching, the black head of the larva is visible through the egg shell. This is known as the "black spot" stage. The eggs are circular or oval in outline, scale-like, somewhat convex and with flattened edges. They hatch in from four to fifteen days. They are usually deposited on the underside of the leaves in the case of peach, although some eggs are found upon the upper surface. (See Fig. 5). In the case of quince they are always found upon the upper side on account the hairy surface beneath. Eggs may also be found on the stems of new shoots of quince and peach and at the calyx of quinces and apples.



Fig. 4. Cocoons on the under side of peach bark. Note worm and pupal stage in figure at left.

The Larvae. In general appearance the larvae or worms resemble the codling moth larvae. They are somewhat smaller however, measuring about one-half inch in length when full grown as compared with three-quarters of an inch for the codling moth. (See Fig. 6). They vary in color during the different stages of development, the younger larvae are a dirty cream color, varying to pink which is intensified as they grow older. Many mature larvae however have a yellowish rather than a pinkish tinge.

Upon hatching the young larvae immediately start out to find favorable feeding places in the terminals or fruit. The length of time for the larvae to develop fully is usually eight to twelve days.

Late in the season, larvae in fruit especially apples or quinces may require a month or more.

The first two generations of larvae (there are four or five altogether) feed mainly in the terminals of peach, cherry and quince, although in some cases and especially where the trees are old and the twig growth slight, many larvae of the first generation enter the small peaches. Larvae may be found feeding in terminals throughout the season on trees with late tender twig growth but as the terminals harden in late July and August and the fruit, if any, approaches maturity, the great bulk of the larvae enter the fruit. As stated before, the larvae of the later generations feed not only in peaches but in quinces and apples as well. While serious infestations have not been observed in apples in our work, there appears

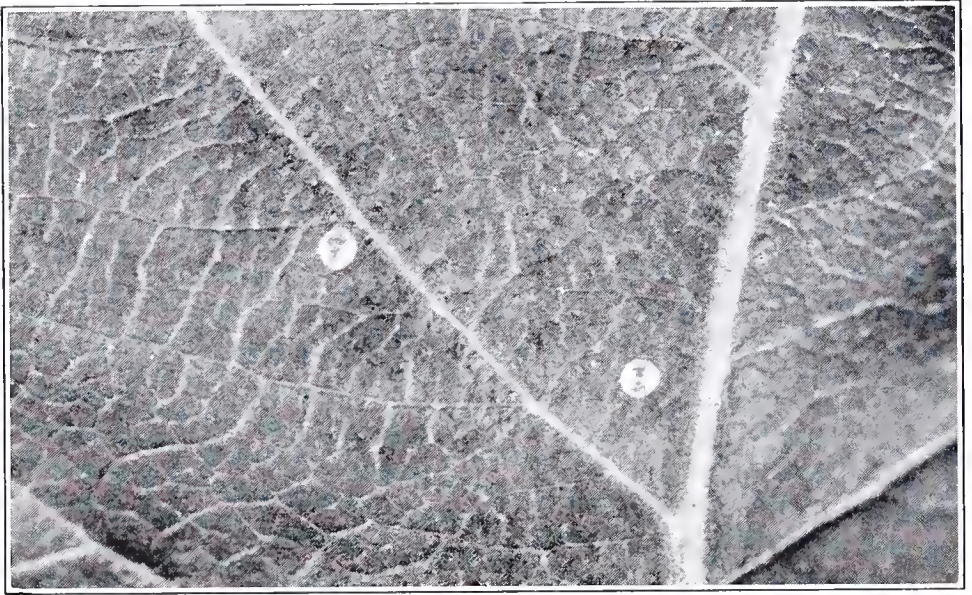


Fig. 5. Eggs of the Oriental fruit moth highly magnified.

to be a considerable migration of Oriental fruit moth adults to apple orchards late in the season, especially after the peach crop is harvested. It is at this time that most of the injury on apples occurs.

The full grown larvae of the summer generations, when leaving the fruit or terminals to transform, prefer to form their cocoons on the sides or between the fruits where they utilize the fuzz or hairs on the fruit together with their silk in making the cocoon. Fruit baskets and corrugated paste board covers are also favorite places for pupation. Larvae of the later generations coming from picked fruit are found in such places and this no doubt constitutes an important means of spread of the moth.

The Pupae. The pupae are yellowish brown in color, smooth, with an average length of one quarter of an inch. The pupal or quiescent period averages eight days. (See Plate II).

When the moth is ready to emerge the pupa pushes its way almost from the enclosing cocoon and attaches itself to the cocoon. The pupal case then splits and the moth emerges.

The Adult or Moth. The moth is somewhat smaller than the codling moth although resembling it in many respects. It has dusky brown mottled wings which are folded against the body when the moth is at rest. The wing spread is about three eighths of an inch. (See Fig. 7).

The moths are active fliers and are no doubt carried long distances with the wind, thus helping in their local spread. For the most part they remain at rest in the trees during the day, flying in the late afternoon and evening or early in the morning if the weather is warm. On several occasions moths have been observed flying in large numbers during the day. A heavy flight was observed in three different orchards in the vicinity of Harrisburg on May 6th, 1924. From ten o'clock in the morning until noon, large numbers of the moths were seen flying about the trees and numerous pairs were mating. The habit of daylight flying was noted several other times throughout the season, although at no later time was the number of moths nearly so great as in the first flight.

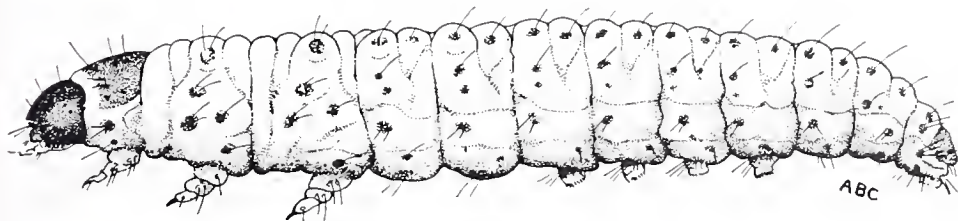


Fig. 6. Drawing of the larva of the Oriental fruit moth.

NATURAL ENEMIES

The Oriental fruit moth, especially in the larval stage, is attacked by a large number of parasites. About twenty-five different kinds of parasites have been reared in the past four years in southern Pennsylvania. Of these only three or four are of more than minor importance as yet.

From the time the first records were made in 1925, there has been an increase in the percentage of parasitism each year until 1928 when a decrease was noted. The records for each year are given in Table 2. The figures are for larvae from terminals. Larvae from fruit are parasitized to a very slight degree. In 1928 in August and September while 1774 adults were reared from terminals with a parasitism of 9.3 per cent, 393 adults were reared from larvae in fruit with a parasitism of 1.2%.

The largest portion of larval parasitism thus far is due to two species: *Macrocentrus ancylixora* Roh. and *Glypta rufiscutellaris* Cress. The proportion of these two parasites to the total number reared is shown in Table 3.

Table 2. Parasitism of larvae from terminals during 1925, 1926, 1927 and 1928.

Year	June			July			August			September			October		
	Moths		Parasites	Moths		Parasites	Moths		Parasites	Moths		Parasites	Moths		Parasites
	No.	Per cent		No.	Per cent		No.	Per cent		No.	Per cent		No.	Per cent	
1925	137	0.7	1	183	1.6	3	249	2.7	7	78	3	3.7	44	63	58.8
1926	15	0.0	0	145	0.7	1	172	4.6	8	477	84	14.9	9	22	70.9
1927	123	0.8	1	1,121	2.6	30	389	21.9	112	60	50	45.4			
1928	45	0.0	0	1,560	0.9	14	1,201	5.4	69	573	113	16.4			

Table 3. Proportion of parasitism due to various parasites.

Year	Macrocentrus anelytvora			Glypta rufisculularis			Other parasites		
	No. of Parasites		Per cent	No.		Per cent	No.		Per cent
	No.	Per cent		No.	Per cent		No.	Per cent	
1926	164	103	62.8	58	35.3	3	1.9		
1927	214	12	5.6	185	86.4	17	8.		
1928	196	55	28.	110	56.1	31	15.9		

Another important parasite, *Trichogramma minutum* Riley, attacks the eggs. Of 921 eggs collected in 1928, 550 or 59.7% were found to be parasitized by this species. The percentage of parasitism is low early in the season but rises rapidly until late in the season nearly all eggs found are parasitized. The percentage of egg parasitism for the different months in 1928 is as follows: June 3.8%, July 34.1%, August 54.4%, September 84.8%, and October 96.5%.

This parasite offers some possibility of control by artificial propagation early in the season since it is apparently not able to survive the winter as far north as Pennsylvania.

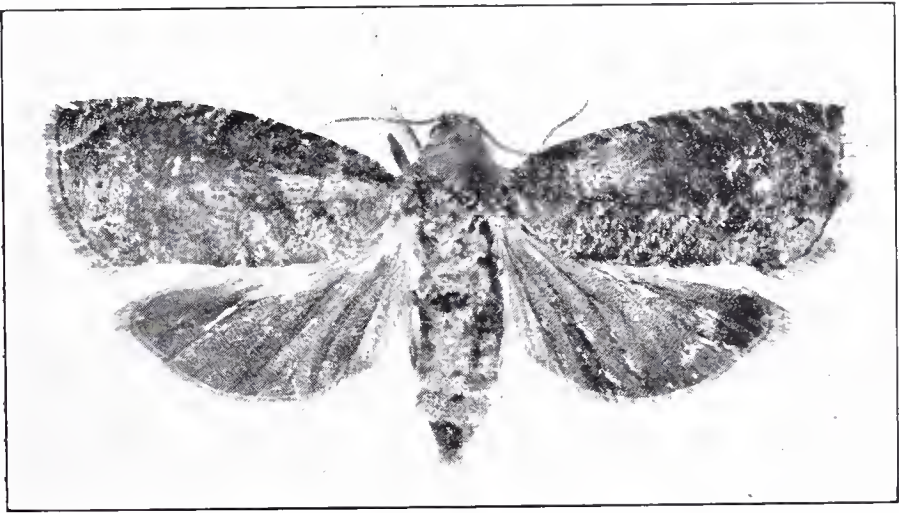


Fig. 7. The moth or adult form of the Oriental fruit moth greatly enlarged.

CONTROL MEASURES

Thus far there is no satisfactory method of control for the Oriental fruit moth. The feeding habits of the larvae make them almost immune to poisons since they do not feed until they penetrate into the terminals or fruits where it is impossible to reach them with a poison.

Nicotine sulfate as a contact spray against the eggs and newly hatched larvae has reduced the amount of wormy fruit by a third or more when as many as six applications have been made at the rate of one pint nicotine sulfate to one hundred gallons of spray. It is questionable, however, if it is profitable to use nicotine sulfate considering the expense of the operation, the small percentage of control obtained and the uncertain returns. Where it is desired to use nicotine, the following schedule should give as effective control as any:

1. Shuck fall spray. Nicotine sulfate, 1 pint and two pounds arsenate of lead powder to one hundred gallons of self-boiled or

Jersey "Dry Mix" lime and sulfur. This spray is part of the regular peach schedule.

2. Same as for No. 1, ten days to two weeks later.

3. Nicotine sulfate, 1 pint to one hundred gallons water with four pounds laundry soap. One week after No. 2.

4. Same as for No. 3 one week later.

5. Same as for No. 4 one week later.

All applications are timed against the first generation and at close intervals to reduce the first generation to a minimum.

In small plantings a measure of control may be secured by removal of the infested twigs in the early spring. All infested terminals should be removed but especially the ones showing the first signs of wilting as the larvae soon leave injured terminals and go to fresh ones. To be most effective, twig collections should be made at least once a week and preferably twice a week over a period of four weeks from the time the first injury is noticed. Infested twigs should be burned at once after removal.

Practices which may aid in reducing the number of overwintering larvae should be followed as far as possible. Early cultivation prior to blooming is advised to cover up larvae and pupae in trash on the ground before the adults emerge. Cage experiments in New Jersey have shown this to be a good practice. PDB (paradichlorobenzene) which is now quite generally used against the peach borer has also been found to kill Oriental fruit moth larvae which spin up at the base of the trees.

Infested fruit removed during thinning and culled out during packing should be destroyed the same day to prevent the escape of larvae they may contain. Probably as good a way to do this as any is to bury the fruit in a sink hole or pit and cover over with hydrated lime or three or four inches of earth.

Screening of the packing house would also shut off a source of infestation since large numbers of larvae winter over in crates, baskets, corrugated paper covers, etc. On one occasion the writer gathered a five-eighths hamper of infested quinces. The quinces were left in the hamper two days and were then removed. During the two days, however, 83 larvae left the quinces and spun up in cracks of the hamper.

As a control measure against the adults, bait pans with molasses or syrup diluted with 10 or 20 parts of water have been tried out during the past three years. While large numbers of adults are caught in the pans no consistent reduction of wormy fruit has been secured where bait pans were used.

A fine grade of lime used often enough during the early part of the season to maintain a coating gave promising results in work

carried on by Dr. Stearns. Three heavy applications on July 3rd, July 18th and August 3rd gave no apparent control in work carried on at Chambersburg in 1928. However, Dr. Stearn's work was carried on against the first brood and further work may prove lime to be of great value.

CONTROL OF THE MOTH IN OTHER FRUIT

The Oriental fruit moth infests quinces heavily and, where apples and peaches are interplanted or adjoining, may infest apples. Thus far no injury of commercial importance has been observed on apples in Pennsylvania. Although arsenate of lead has little effect in protecting peaches, it appears from tests made at the Chambersburg laboratory that arsenate of lead on apples does give some protection. On July 28th, twenty apples were sprayed with arsenate of lead at the rate of $1\frac{1}{2}$ lbs. to fifty gallons. Twenty apples were left unsprayed. A newly hatched larva was placed on each of the apples. Two weeks later when the apples were examined for injury it was found that of the twenty larvae on the sprayed apples, only two had entered the fruit and both of them had died, while of the twenty larvae on the unsprayed apples, 12 had entered and eight of the twelve had matured.

In small plantings of quinces the fruits may be successfully protected by covering them with paper bags. In the season of 1924 bags placed on quinces in the first week of July gave perfect protection to the quince fruits while bags placed the second and third week of July enclosed fruits which contained larvae. These fruits were usually not reinfested however by a later generation. The bags used in covering the quinces must be tough enough to remain entire throughout the growing season. Other fruits commonly grown in Pennsylvania such as cherries, plums and pears have suffered very little injury from the Oriental fruit moth.

